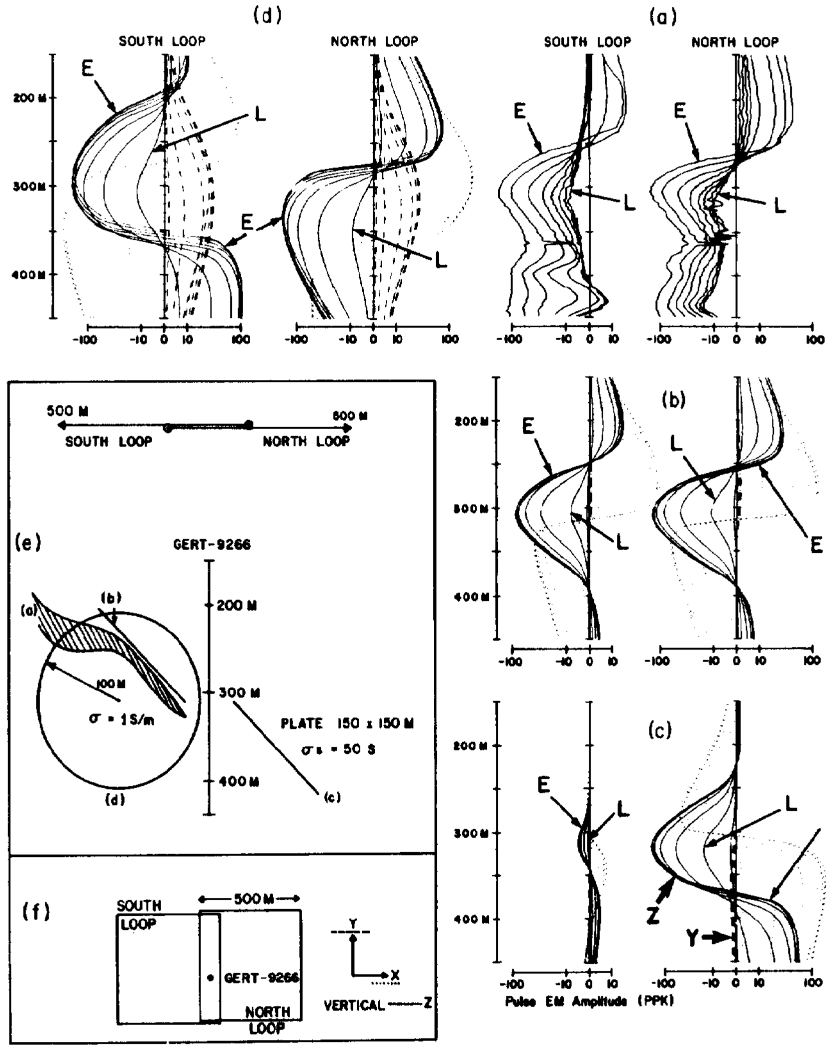

FIG. 4. Plate and sphere models compared to field data from GERT-9266. (a) Crone Pulse EM field data. (b) Updip plate. (c) Downdip plate. (d) Sphere. (e) Section. (f) Plan and component legend (note compressed scale). Amplitudes are continuously normalized to axial primary field. Models are placed symmetrically with respect to N-S section through GERT-9266.

conductor on each side of the hole. The south-loop response is different as the downdip plate is only weakly coupled to the transmitter. When the poorer conductor lies downdip it goes virtually undetected. When the better conductor is downdip it has a noticeable effect on the late-time response. Whereas the location of the lower conductor is extremely difficult to determine from the Z component, the X component resolves the ambiguity completely. Model results shown in Figure 4 for the Gertrude deposit (Sudbury, Ontario) serve to illustrate the hypothetical application of transverse components. For example, the up or down-dip location of the conductor could have been uniquely determined using the sign change in the X-component anomaly.

The modeling work carried out in this study is hopefully ample encouragement for the development of three-component, wideband, magnetic field sensors and the accompanying orientation hardware. Interactive computer modeling of simple conductor shapes can provide the facility for interpreting what will be a considerably more complicated data set.

Reference

Dyck, A. V., 1981, A method for quantitative interpretation of wideband, drill-hole EM surveys in mineral exploration: Ph.D. thesis, Univ. of Toronto.

Automated Interpretation of Airborne Electromagnetic Data M1.6

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Recent improvements to Input Mark VI instrumentation resulted in an accurately calibrated, highly precise, system for airborne electromagnetic exploration. The time-domain data produced by this equipment can now be interpreted in terms of the parameters of a two-layer model (one layer over a half-space) of the survey area. The entire interpretation procedure is carried out on a computer in an efficient, noninteractive manner.

While experience with the new technique has been limited, the results obtained to date are quite encouraging. Tests of this method as applied to data sets from two surveys in Canada indicate that time domain EM data can be automatically interpreted to yield the electrical parameters of the surficial materials.

The interpretation method presented here allows for differentiation of surficial materials, indicates possible subsurface structure, and facilitates the discovery of subsurface conductive features whose presence is only discernible with difficulty in the original data.

In this system, the secondary field transient is recorded at six instances after the primary field pulse has been turned off. These six amplitudes, which characterize the decay of currents induced in the ground beneath the aircraft, are averaged over about 300 repetitions of the primary pulse and are digitally recorded every half second. Also placed on the digital record is the reading of the aircraft radio altimeter. To ensure data quality control, a continuous analog record of the radio altimeter and the six channel amplitudes is available for immediate inspection during flight.

The time-domain data produced by this equipment can now be interpreted in terms of the parameters of a two-layer model (one layer over a half-space) of the survey area. This interpretation model allows for differentiation of surficial materials and indicates possible subsurface structure. By using this interpretation model to synthesize an appropriate regional or background EM response for the survey area, and subtracting this regional response from the observed EM channel amplitudes, the geophysicist may quickly identify subsurface conductive features whose presence is only discernible with difficulty in the original data.

To determine the parameters of a two layer model providing a best fit to a given data scan (the six EM channel amplitudes and the altimeter reading,) an extension of the nomogram fitting technique of Palacky (1973) is employed. First, nomograms are constructed for the uniform half-space model and 25 additional two-layer models. The parameters which define the two-layer nomograms are the thickness of the layer and the conductivity contrast between the layer and underlying half-space. The input to a nomogram is the data scan. The 26 nomograms are accessed sequentially in a hierarchical manner designed to minimize excursions from the uniform half-space interpretation model. In this way, the first nomogram for which an acceptable fit to the observed EM channel amplitudes is obtained is deemed the proper interpretation nomogram. From this nomogram is determined the depth to and the conductivity of the two-layer model. As successive data scans along a flight line are fit to a nomogram, a profile of two-layer interpretations is obtained.

With this profile of two-layer interpretations, it is possible to (1) remove from consideration those anomalies in the EM channel amplitudes due solely to the variation of the aircraft altimeter, (2) calculate regional or background EM channel amplitudes along the profile, and (3) calculate residual or anomalous EM channel amplitudes along the profile. First, the effect of a nonconstant altimeter must be removed from the data. An average altimeter reading over a short section of the line is used as a datum, and for each model of

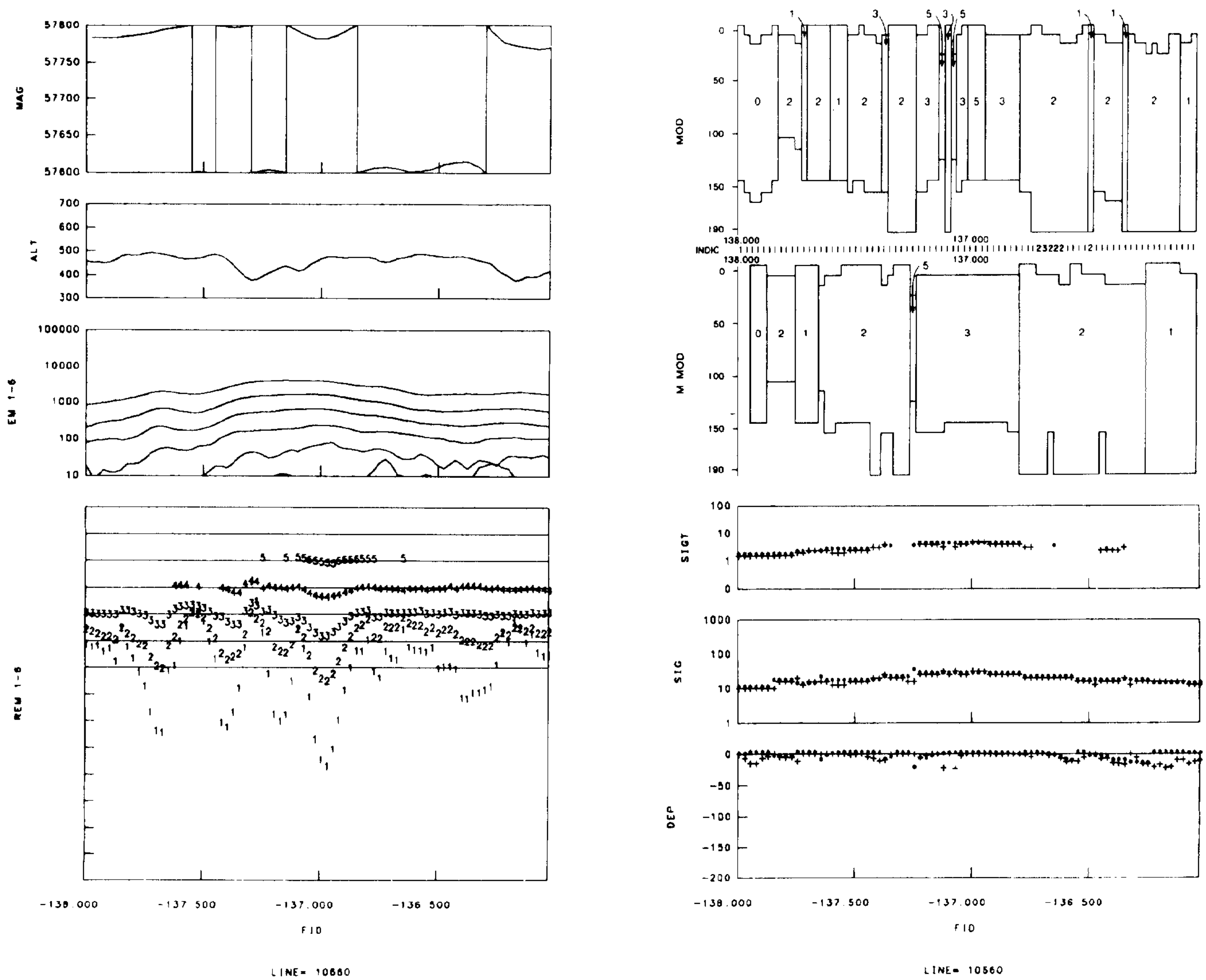

FIG. 1.

the profile the corresponding "altitude leveled" EM channel amplitudes are synthesized. These amplitudes are then passed through a 21 point filter whose output is the median amplitude of each of the EM channels. Of the 21 models supplying the input to the filter, the median model is defined as the model for which "altitude leveled" EM channel amplitudes are closest to the median EM channel amplitudes. The regional or background EM channel amplitudes may be obtained from the median model at any altitude. Finally, residual or anomalous EM channel amplitudes are calculable by simply subtracting the regional EM channel amplitudes from the observed EM channel amplitudes. Tests done on the same line flown at different altitudes and in different directions indicate that the calculated residual EM channel amplitudes are qualitatively consistent.

Figure 1 shows a typical interpretation of a portion of line 10660 from an Input survey in British Columbia. This portion was chosen for an initial interpretation because it crosses a geophysical grid surveyed on the ground using the Crone PEM and MAX-MIN electromagnetic prospecting systems. The various diagrams in Figure 1 relevant to interpretation are identified as follows. Starting at the upper left-hand corner and working downward: MAG shows the magnetometer reading in gammas, cycled over at 200 gamma intervals. ALT is a plot of the altimeter reading in feet. EM 1-6 shows the original data in ppm plotted on logarithmic scales. Note that channel amplitudes increase upward and that channel 6 appears at the bottom of the diagram. REM 1-6 is a plot of the residual EM amplitudes in ppm. The scale is linear. Channel 1 appears at the bottom of the diagram and amplitudes increase downward. The scale is 200 ppm per division. FID is a measure of time along the flight line. One FID equals about 1100 m at the nominal aircraft velocity.

Starting at the upper right-hand corner and working downward: MOD is a plot of the obtained two-layer interpretation profile. The numbers 0-9 in the body of the plot represent spatially the conductivities of the two-layer models comprising the profile. The scale for conductivities is logarithmic. The number 0 equals 13, number 9 equals 100 millisiemens/meter. Conductivities less than 10 ms/m are not plotted. Depths in meters are plotted linearly and are read in the left margin. INDIC is an indication of the fit of the data to the two layer interpretation model; 1 indicates a fit to 3 percent rms, 2 indicates a fit to 5 percent rms, 3 indicates a fit to 7 percent rms. M MOD is a plot of the two-layer median model profile. Depths and conductivities are the same as for MOD. SIGT is a plot of the conductivity thickness product of the overburden for the case of a conductive layer over a resistive basement. The scale is logarithmic and reads in Siemens, + denotes the values for MOD, * the values for MMOD. SIG is a plot of the maximum conductivity in the section. The conductivity scale is logarithmic and reads in millisiemens/meter, + denotes the values applicable to MOD and * denotes the values applicable to MMOD. DEP is a plot of the depth to the maximum conductivity in the section. The scale is linear and reads in meters, + denotes the values applicable to MOD and * the values applicable to MMOD.

Figure 2 shows the relation of the airborne survey lines to the ground survey grid. Anomalies in the airborne data originally identified without the use of the residual EM interpretation technique are shown as open circles. Residual EM anomalies are shown as X. The location of a conductor interpreted from the ground data is shown in dotted lines and solid circles.

The residual EM anomalies shown in Figure 2 line up quite well along the axis of the conductor interpreted from ground data. The regional conductivities obtained from the median model profile of Figure 1 are consistent with results of a Schlumberger resistivity sounding 2 km to the southeast, Figure 3.

While experience with this new technique is limited, results obtained to date are quite encouraging. Tests of this method as applied to data sets from two surveys in Canada indicate that time domain electromagnetic data can be automatically interpreted to yield the electrical and geometric parameters of the surficial materials. Calculation of the residual or anomalous EM channel amplitudes along a profile appears to be an effective means of mapping subsurface conductive features whose presence is only discernible with difficulty in the original data.

Acknowledgments

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References

Palacky, G. J., and West, G. F., 1973, Quantitative interpretation of Input AEM measurements: Geophysics, v. 38, p. 1145-1158.

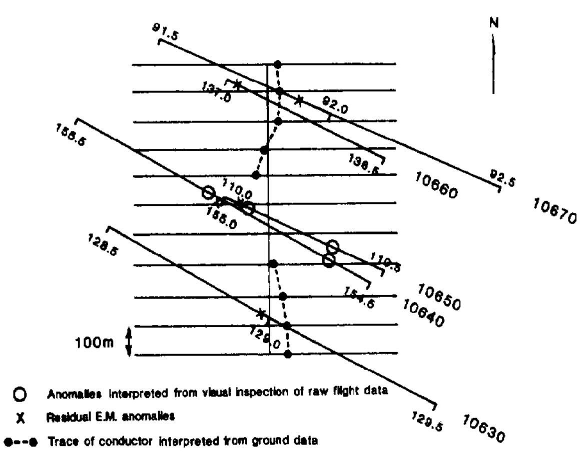

FIG. 2. Relation of airborne survey lines to ground survey grid.

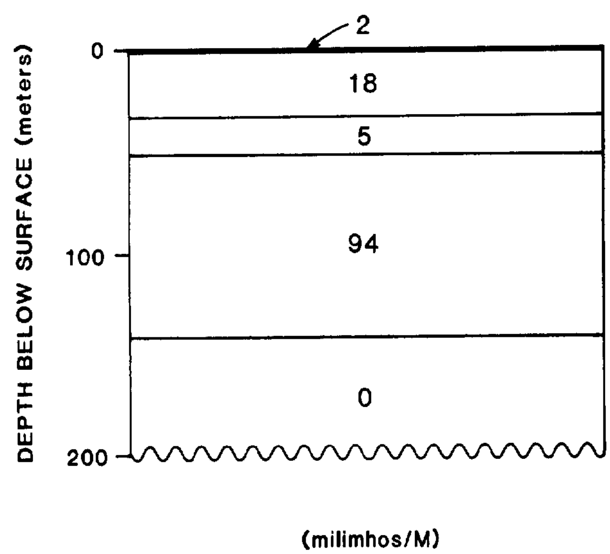

FIG. 3. Geoelectric structure inferred from least-squares inversion of Schlumberger sounding.